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Origins and evolution of the National Nutrient Databank Conference

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Abstract

Food composition tables are largely a twentieth century product. The early tables in America developed by W. O. Atwater in the 1890's at the Storrs Connecticut Agricultural Experiment Station grew exponentially during the first half of the 20th century as one after another vitamin and mineral was found to be essential for life. As tables became more complex the user required better tools for calculating food composition. The rapid growth of computer applications in the mid to late 20th century allowed nutritionists to access these complex tables. This confluence of data and computer applications spawned an organization created specifically to study food composition databases.

Peer-review under responsibility of the National Nutrient Databank Steering Committee

Keywords: Nutrient Data; Food Composition

1. Introduction

The National Nutrient Databank Conference evolved to satisfy a need in the nutrition community. In the 1970's the accumulation of dietary data over the previous 80 years had resulted in massive databases too big for manual calculations. But fortunately emerging automatic computer capability was becoming available. The potential for automated nutrient calculations was eagerly anticipated by practicing nutritionists but combining the two technologies did not solve all the old problems, and contrary to expectations it created new ones.

By lucky happenstance a group of dedicated workers in government and clinical nutrition came together to form an organization to study and campaign for strategies to resolve the evolving issues, and that organization has lasted for over 40 years. Two newcomers to the field of computer applications, a physician (Dr. Donough O'Brien) and a dietitian, (Ms. Joan Karkeck) were catalysts for the meeting that led to an annual conference. Their pleas were heard by others and the combined interests of numerous specialists eventually led to an organization called the National Nutrient Databank Conference or NNDC. But to fully appreciate how such a long lasting organization could emerge from seemingly random encounters we need to go back a couple of centuries. The following historical snapshot suggests that the time was right in 1976 for developers and users of nutrient data to step forward.

2. Identifying and Documenting Food Composition

The tremendous amount of food composition data we take for granted today was not always available. In 300 BC Hippocrates ventured the notion there was one element in food that nourishes. He based this idea on the observation that people living near the sea ate exclusively food from the sea and were healthy, yet those living inland were just as healthy living only on food from the land. Therefore, logically, there must be something in all foods that nourishes. Nothing is reported to confirm this observation for almost 2000 years. Fast forward two centuries when we find records in at least three different European countries documenting multiple nutritional components in food identified by a new science, chemistry.

In 1827 England William Prout, working in the fledgling field of chemistry, identified three primary components of food he termed saccharinous, albuminous, and oliginous (for carbohydrate, protein and fat) to describe the components he identified in food.

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Unfortunately physiologists dominated the medical field in England at that time and they were not receptive to new ideas from chemistry, a rival field. Prout predicted that chemistry would eventually transform medicine, that knowledge of chemistry would be as valuable to the physician as anatomy was to the surgeon.[1] He did not live long enough to see his prediction come true, but others who came after him proved him right. More established chemists in France and Germany were also working in this new field, known as "nutrition", and they received a more receptive audience. Antoine Lavoisier in France[2] and Justus Von Liebig in Germany[3] were conducting experiments to measure changes occurring as food was converted to energy in the body. Protein was considered the primary source of energy for conducting work.

Timing and ambition were just right for an industrious and talented son of a Methodist minister in America in the late 1800's to begin working in the field of nutrition. Wilbur Olin Atwater was born in New England in 1844 and by 1885 was a chemistry professor at Wesleyan University in Middletown Connecticut. By this time he had studied in Europe primarily with Carl Voit in Germany (a protégé of Liebig). Atwater's ambition was to study nutrition among American workers with the goal of recommending the most economical diet[4]. Nutrition thinking of the time was that protein was needed to provide energy but protein sources were the most expensive food items, and food already consumed over half the worker's income. Atwater was convinced he could improve the economy of the American family by studying their food intake and expenditure and recommending a thrifty diet. From his studies in Germany he was well versed in the tools needed to conduct studies in America. With his knowledge and ambition he was a natural choice to lead the newly formed Agricultural Experiment Stations in America.

But the road to science was a bumpy one as explained by Judy McBride in an Agricultural Research Magazine[5], She wrote "In early 1893, the odds that Wilbur Olin Atwater would get public support for his grand plan for food investigations were slim to none". His eventual success in attracting funding was attributed to intercession of Edward Atkins of Boston who was a close personal friend of the Secretary of Agriculture who would decide funding, and Atkins was well aware of Atwater's potential contribution to food economy. Atkins was a self-taught economist who published widely on economic issues and understood what Atwater could add to the current knowledge about food economy. He encouraged the Agriculture Secretary to fund human nutrition research in America. In McBride's words, this recommendation was instrumental in "prying open the door for the first federal funding of human nutrition research in the United States". But Atwater himself had to pursue this recommendation vigorously for another year before he was finally granted $10,000 for food investigations. Atwater established a laboratory at the Storrs Connecticut Experiment Station and began his studies, which fortunately attracted attention from other sources of funding; the National Fisheries contracted for a study of the composition of fish and the Smithsonian Institute provided funding for other food analyses.[6]

This led to the first comprehensive food composition table, probably in the world. Earlier food tables were limited by the available data which was largely inorganic constituents and organic acids[7]; the Atwater tables were comprehensive (5 components, the "proximates") for hundreds of foods.

The variety of foods in the tables was so great that Atwater was later able to supervise nutrition studies all over America. The first table was published as USDA bulletin 21 in 1895. This document contained detailed descriptions of sample preparation and observations on characteristics of food in different stages of preparation plus data on protein, fat, moisture and ash plus carbohydrate by difference (the "proximates") for selected foods. The next year a comprehensive summary of all the food analysis data was compiled by Atwater and CD Woods and published as Bulletin 28, also by the USDA Experiment Station[8]. This work is mentioned in detail because it represents an amazing accomplishment in such a short time. Food composition data available before this had taken centuries to be developed. Atwater was simply at the right place at the right time and had the conviction of purpose to grab the opportunity and exploit it. Comprehensive tables were later developed in the U.S. and other parts of the world. Notable were Bowes and Church in the U.S.[9] and McCance and Widdowson England[10] during the 1930's and Souci in Germany[11] in the 1960's. Today the Food and Agriculture Organization of the United Nations lists dozens of food composition tables from countries around the globe (http://www.fao.org/infoods/infoods/tables-and-databases/en/).

Analyzing food and developing a table of food composition depends on the technology available. In the 1890's Atwater fashioned equipment needed for this work including a bomb calorimeter for measuring energy in food and a room-sized calorimeter to measure human energy expenditure. He conducted or directed the analyses of numerous food stuffs and quickly became aware of the variability in the composition of food caused by factors such as cut of meat and recipe for prepared foods. He took advantage of the World's Fair in Chicago in 1893 to acquire samples of meat for analysis from all over the world. As data on food composition became available, for the first time it was possible to calculate the energy required by a person at work in their natural environment from a record of food intake. While this was of scientific interest, it was not of immediate public value, so Atwater was pressed to show more relevance to his work. He was assigned broader responsibilities, which included supervising nutrition studies in all the experiment stations to bring this science to a wider audience[4]. Tabulating this data was time consuming, but with only six components to manipulate pencil and paper and a mechanical calculator was sufficient for scientific work.

However, between 1910 and 1940 many more nutritive components were identified and measured. Table 1 gives a snapshot of the growing list of known nutritive components in food. In 1963, after reviewing available data, the USDA Agricultural Research Service published the most relevant information in a booklet called "Handbook 8, Composition of Foods" with data for 2483 foods for 20 components. The foods were listed in 100 g portions which hampered wide usage, but nonetheless the data were utilized for many purposes including menu planning, research, and education.

3. Computerizing Food Composition Databases

Concurrently there was rapid development of electronic devices for manipulating numbers. The first computers available for manipulating food composition data were housed in government, academic and industry and were room-sized to be shared by many

people within the organization. These tools would put food composition data to work solving practical problems. Institutions such as hospitals, government agencies, food producers and colleges and universities began to create computer programs to process the newly available data.

About this time two individuals with similar interest and determination to develop nutrition applications to support their own work were searching for resources. They spearheaded a meeting with others of similar interests to encourage combining resources to remove some of the road blocks to electronic processing of food composition data. The first individual, a physician named Donough O'Brien from the University of Colorado Medical Center and chair of the American Academy of Pediatrics Committee on Nutrition, had a FDA grant to "improve the knowledge of nutritional intake and nutritional status by expanding the use of the computer in providing nutrient

Table 1. Discovery dates of the vitamins and their sources and dates for recognition of the essentiality of minerals[1,2]

Year of Discovery	Nutrient	Food Source
1913	Vitamin A (Retinol)	Cod liver oil
1910	Vitamin B_1 (Thiamine)	Rice bran
1920	Vitamin C (Ascorbic Acid)	Citrus, most fresh foods
1920	Vitamin D (Calciferol)	Cod liver oil
1920	Vitamin B_2 (Riboflavin)	Meat, dairy products, eggs
1922	(Vitamin E) (Tocopherol)	Wheat germ oil, unrefined vegetable oils
1926	Vitamin B_{12} (Cobalamins)	Liver, eggs, animal products
1929	Vitamin K_1 (Phylloquinone)	Leafy green vegetables
1931	Vitamin B_5 (Pantothenic acid)	Meat, Whole grains, in many foods
1931	Vitamin B_7 (Biotin)	Meat, dairy products, eggs
1931	Mn and Mg essential for rat	
1934	Vitamin B_6 (Pyridoxine)	Meat, dairy products
1934	Zinc essential for rat	
1936	Vitamin B_3 (Niacin)	Meat, grains
1941	Vitamin B_9 (Folic Acid)	Leafy green vegetables

[1] vitamin dates from: http://en.wikipedia.org/wiki/Vitamin#History
[2] mineral dates from: Darby WJ (1984) Ann Rev Nutr 5:1-24.

information in a manner usable to the dietitian and the physician in clinical practice in the care of sick children."[12] He found the greatest barrier to computerizing food composition data was lack of appropriate food data for his pediatric population. Dr. O'Brien began a search for other individuals interested in expanding availability of food composition data and began asking for help from colleagues and acquaintances in similar fields and especially sought the support of USDA who was actively involved in food composition data compilation. His search for support led him to the second individual with a keen interest in this topic, Ms. Joan Karkeck at Harborview Medical Center in Seattle, Washington. Ms. Karkeck needed help in developing food composition applications for the medical center where she worked and to support her work with a group in Alaska who were studying the local population and facing a lack of food composition data for native Alaskan foods.

As Ms. Karkeck and Dr. O'Brien pursued their common problems they found a receptive ear at the United States Department of Agriculture. Dr. Robert L. Rizek, Chair of the Consumer and Food Economics Institute, Agricultural Research Service and director of the 1977-78 Nationwide Food Consumption Survey, was also interested in improving availability of reliable food composition data. As the critical mass grew a meeting was planned in Seattle, Washington financed by the American Dietetic Association and attended by 30 invited participants including O'Brien, Karkeck, Rizek and Dr. Loretta Hoover from the University of Missouri. Dr. Hoover was actively involved in computerizing applications requiring food composition data at her institution, and had agreed to present her experiences and insights to the group. This meeting was called the "National Invitational Conference on Development of Nutrient Data Bases" and held April 15-16, 1976.[13]

The potential power of the computer to increase the value of food composition data was quickly recognized and in 1977 Rizek announced the availability of Handbook 8 in electronic form. This was a great step forward, but users soon found that having the data was not enough. Karkeck explained this problem in her remarks at the second NNDC meeting titled "Day-To-Day applications of health professionals – Part I[14]". She started the meeting with a short story about her experiences with electronic data processing:

> We started with an extensive database in the [hospital] archives not being used [Handbook 8]. We had the material and we didn't have any expertise …. And nobody had any funding to support the idea. We recruited eight other interested groups to share development costs, and asked them to recruit other users to further support development cost. Meanwhile we started our own development. But problems remained even after we successfully developed our first database application. We introduced our dietitians to our first application by giving them a manual on how to use the database, written by our computer people. …. After some frustrating attempts to use the application our dietitians came back and said "Cancel this!" Then we had a dietitian familiar with the programming write a new user manual…and that way it worked. …. But our second aim; increasing the size of our user base to help with funding, was more difficult. Because of computers being what they are, everybody had their *natural inborn resistance*.

Mary Farley, also from the Harborview Medical Center in Seattle, continued this discussion with "there were lots of issues to talk about in the early meetings, issues that were new to first-time databank users like Utah Swiss steak has gravy and mushrooms, whereas Minnesota uses a tomato sauce." Or that "a peanut butter sandwich is easy to code if listed as a unit (i.e. a sandwich) in the database, but was not as precise as listing the individual ingredients, such as 2 ½ tablespoons peanut butter, 1 tablespoon jelly, and 2 slices whole wheat bread; 16 slices/pound."[15]

Other issues emerged during the second NNDC. Four task forces reported on common issues: (1) Expansion of nutrient data for users and for providers, (2) Computerized Nutrient Data – identifying existing programs, (3) How to fund and administer Nutrient Databases and (4) Propose a system for sharing nutrient information.

At the same time Dr. Hoover suggested that conference participants with nutrient calculation systems should compare printouts and data by evaluating a simple menu expressed in common units. Eleven participants agreed to calculate composition of the menu and share results.[16] Because of the great differences found in the data generated from this common menu the comparison was conducted three times, each trial adding more specificity to the menu to reduce the possibility that poor food descriptions were causing the discrepancies. For example, for the 1st trial the food "ham" was listed. For the 2nd trial, the food was described as "ham, 1 oz or 28 g"; and for the 3rd trial it was further described as "ham, 1 oz or 28 g, cooked, separable lean-light cure, medium fat class." Even with the detailed descriptions provided for the 3rd trial, large differences remained among the eleven databases, with energy ranging from about 1945 calories to over 2300 calories suggesting that improvements were needed in the databases or the technology or both.

3. Recent NNDC Accomplishments

3.1. Nutrient Databank Directory

Over the years the conference has continued to provide scientific services to participants. Attendees at the 5th NNDC received a Nutrient Databank Directory that listed 29 food composition computer applications. The consolidated information was compiled by Donna Hay and Tony Fisher from the University of Missouri. This directory underwent numerous revisions directed by Loretta Hoover and more versions by Jack Smith, University of Delaware and others. The second edition of the Nutrient Databank Directory edited by Loretta Hoover and Tony Fisher and distributed at the 7th Annual NNDC illustrates the diversity of the work being done. This directory listed 39 Nutrient Databases containing between 37 and 12,000 foods and between 4 and 102 components. The directory gave contact information, program languages the applications were written in, the computer they were designed for and how they could be accessed (i.e., purchased, leased, contract services).

One important piece of missing information was completeness of the data for each food. The method for handling missing values was to give a blank or zero by 29 of the 39 applications; only 8 applications provided an estimate when actual values were unknown. Users soon discovered that having thousands of foods and dozens of nutrients did not mean that all nutrients present in all foods were listed in the database, and when data were limited as they were in many databases, a summary of total intake could be almost meaningless. The limited nature of the information about available software made purchase decisions difficult. During this development phase the National Agricultural Library in Beltsville, MD maintained a nutrition software library where users could familiarize themselves with many applications[17]. This was a valuable resource but it was not convenient for potential users who did not live or work near the library. These new resources were exciting, but could also be disappointing. Work was needed to deliver on the promise of speed and accuracy and the NNDC was a convenient place for anyone interested in food composition to share their work and learn from USDA and others about new resources as they became available.

After the 27th conference in 2003 which was a joint effort of the NNDC and the International Food Data Conference (http://www.ifdc2015.com/index.php), the directory was expanded to include food composition databases world-wide and was renamed the "International Nutrient Databank Directory". In its expanded form many modifications were made to ensure it is accessible and up-to-date. For example, after two manual revisions it was reengineered to allow contributors to continually update their data electronically, and provide free access to the contents from anywhere in the world.

3.2. NNDC Website

The NNDC maintains a website (www.nutrientdataconf.org) that includes information from all conferences except the 12th and includes a link to the international Nutrient Databank Directory. Mimeographed proceedings were available for most of the earlier conferences and are archived on this website. Published proceedings are available for later conferences beginning with the 24th in 2000. Table 2 lists the published proceedings.

4. NNDC Membership

Conference participants come from many disciplines and professions and meetings have been hosted in 20 of the 50 states, the District of Columbia and Canada. Location of the first 30 conferences is listed in an earlier NNDC history[18]. Further details are added by editors for the 36th NNDC held in Houston, TX[19]. The conference met annually for 21 years from 1976 to 1996, but was cancelled in 1997 due to budgetary considerations. As financial limitations continued to threaten the ability of the organization to conduct regular meetings the conference steering committee became incorporated as a non-profit organization in 2004 and a treasury was established to build a cash reserve thus guaranteeing financial security for future meetings.

Table 2. Published Proceedings for the National Nutrient Databank Conference

Conference No. & Year	Volume, Issue	Location	Guest Editor(s)
No. 26, 2000	JFCA Vol. 14, No. 3	U of Minnesota, Minneapolis, MN	John H. Himes
No. 27, 2003	JFCA Vol.17, Nos. 3-4	Washington, DC	Jean Pennington and Phyllis Stumbo
No. 28, 2004	JFCA Vol. 19, Supplement	U of Iowa, Iowa City, IA	Pennington and Stumbo
No. 30, 2006	JFCA Vol. 21, Supplement	Honolulu, HI	Pennington and Stumbo
No. 32, 2008	JFCA Vol. 22, Supplement	Ottawa, Canada	Catherine Champagne
No. 34, 2010	JFCA Vol. 24, No. 8 (8 papers)	Grand Forks, ND	Catherine Champagne
No. 36, 2012	Vol. 2, Procedia	Houston, TX	Phyllis Stumbo and Susanne McNutt

JFCA is Journal of Food Composition and Analysis (http://www.journals.elsevier.com/journal-of-food-composition-and-analysis/)
Procedia is published on line: (http://www.journals.elsevier.com/procedia-food-science/)

5. Summary

Out of a need for accurate nutrition information by a wide variety of users of food composition data (chemists, nutritionists, researchers, food manufacturers, government agencies, educators and practitioners) grew an inclusive organization that concentrates on the tools needed to identify, plan, evaluate and advocate for valid food composition information. Each participant brings their unique perspective to the program. The need for new food composition data continues to evolve as food engineers develop new products, trade with foreign countries introduces new foods, technology evolves requiring food data in new formats, the role of minor components in food are better understood and the impact of nutrition on health is elucidated. The organization thrives on the support of a wide group of dedicated participants in the U.S. and around the globe.

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